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NORTHROP GRUMMAN SYSTEMS CORPORATION

UNITED STATES DISTRICT COURT

CENTRAL DISTRICT OF CALIFORNIA

WESTERN DIVISION

NORTHROP GRUMMAN SYSTEMS CORPORATION, a corporation,

Plaintiff,

v.

SIEMENS AUDIOLOGISCHE TECHNIK GMBH, a corporation; SIEMENS HEARING INSTRUMENTS, INC., a corporation; GN RESOUND A/S, a corporation; GN HEARING CARE CORPORATION, a corporation; OTICON A/S. a corporation; OTICON, INC., a corporation; PHONAK AG, a corporation; PHONAK, LLC, a limited liability company; SONIC INNOVATIONS, INC. a corporation; STARKEY LABORATORIES, INC., a corporation; UNITRON HEARING LTD., a corporation; UNITRON HEARING, INC., a corporation; WIDEX A/S, a corporation; WIDEX HEARING AID CO. INC., a corporation; and DOES 1 through 10, inclusive,

Defendants.

Case No. CV 10-03120 GAF (FFMx)

(1) COMPLAINT FOR PATENT INFRINGEMENT; AND

(2) DEMAND FOR JURY TRIAL

For its complaint herein, Plaintiff Northrop Grumman Systems Corporation ("**Northrop**") avers as follows:

I.
JURISDICTION AND VENUE

1. This is an action for patent infringement arising under the patent laws of the United States, 35 U.S.C. §§ 1, *et seq*. This Court has subject matter jurisdiction under 28 U.S.C. §§ 1331 and 1338(a).

2. Venue is proper in this Court under 28 U.S.C. §§ 1391(b) and 1400(b) because, on information and belief, the Defendants have done and are doing business, and are subject to personal jurisdiction, in this judicial district.

II.
THE PARTIES

3. Northrop is a Delaware corporation having its principal place of business at 1840 Century Park East, Los Angeles, California 90067.

4. Upon information and belief, Siemens Audiologische Technik GmbH is a German limited liability company having a place of business at Gebbertstraße 125, D-91058 Erlangen, Germany.

5. Upon information and belief, Siemens Hearing Instruments, Inc. is a Delaware corporation having a place of business at 10 Constitution Avenue, Piscataway, New Jersey 08854.

6. Upon information and belief, GN ReSound A/S is a Danish corporation having a place of business at Lautrupbjerg 7, DK-2750 Ballerup, Denmark.

7. Upon information and belief, GN Hearing Care Corporation is a California corporation having a place of business at 8001 Bloomington Freeway, Bloomington, Minnesota 55420.

8. Upon information and belief, Oticon A/S is a Danish corporation having a place of business at Kongebakken 9, 2765 Smørum, Denmark.

9. Upon information and belief, Oticon, Inc. is a California corporation having a place of business at 29 Schoolhouse Road, Somerset, New Jersey 08873.

10. Upon information and belief, Phonak AG is a Swiss corporation having a place of business at Laubisrütistrasse 28, CH-8712 Stäfa, Switzerland.

11. Upon information and belief, Phonak, LLC is a Delaware limited liability company having a place of business at 4520 Weaver Parkway, Warrenville, Illinois 60555-3927.

12. Upon information and belief, Sonic Innovations, Inc. is a Utah corporation having a place of business at 4246 Riverboat Road, Suite 300, Salt Lake City, Utah 84123.

13. Upon information and belief, Starkey Laboratories, Inc. is a Minnesota corporation having a place of business at 6700 Washington Avenue S., Eden Prairie, Minnesota 55344-3476.

14. Upon information and belief, Unitron Hearing Ltd. is a Canadian corporation having a place of business at 20 Beasley Drive, Kitchener, Ontario, Canada N2G 4X1.

15. Upon information and belief, Unitron Hearing, Inc. is a Minnesota corporation having a place of business at 2300 Berkshire Lane North, Suite A, Plymouth, Minnesota 55441.

16. Upon information and belief, Widex A/S is a Danish corporation having a place of business at Nymoellevej 6, 3540 Lynge, Denmark.

17. Upon information and belief, Widex Hearing Aid Co. Inc. is a New York corporation having a place of business at 35-53 24th Street, Long Island City, New York 11106-4416.

18. The true names and capacities of the defendants named herein pursuant to C.D. Cal. Local Rule 19-1 as "Does 1 through 10," whether individual, corporate, associate, or otherwise, are unknown to Northrop, who therefore sues said defendants by said fictitious names. Northrop is informed and believes, and thereon alleges, that each of the "Doe" defendants is legally responsible for the events and happenings hereinafter alleged and legally caused injury and damages proximately thereby to Northrop as herein alleged. Northrop will seek leave to amend this Complaint when the true names and capacities of the "Doe" defendants have been ascertained. Defendants GN Hearing Care Corporation, GN ReSound A/S, Oticon

A/S, Oticon, Inc., Phonak AG, Phonak, LLC, Siemens Audiologische Technik GmbH, Siemens Hearing Instruments, Inc., Sonic Innovations, Inc., Starkey Laboratories, Inc., Unitron Hearing Ltd., Unitron Hearing, Inc., Widex A/S, Widex Hearing Aid Co. Inc., and "Does 1 through 10" are hereinafter collectively referred to as "**Defendants**."

III.

BACKGROUND

19. On March 7, 1995, U.S. Patent No. 5,396,560 ("**the '560 patent**") was duly and legally issued in the names of John T. Arcos, Mark T. Core, and James G. Harrison as inventors. A true and correct copy of the '560 patent is attached hereto as **Exhibit A**.

20. Northrop is the owner by assignment of all right, title, and interest in and to the '560 patent, including the right to sue for past infringements thereof and to seek damages and equitable relief for such infringements. Since its issuance, the '560 patent has been and remains in full force and effect.

21. The '560 patent relates to a hearing aid incorporating a novelty filter. Among other things, the patent recites claims to a hearing aid, an amplifying circuit, and a method of amplifying an acoustical event.

IV.

CLAIM FOR RELIEF

(Infringement of U.S. Patent No. 5,396,560)

22. Northrop re-alleges the averments of paragraphs 1-21.

23. On information and belief, each of the Defendants has made, used, offered for sale or sold in, or imported into, the United States, hearing aids having an amplifying circuit. These hearing aids include, without limitation, the Siemens Motion 500M, the GN ReSound Canta 780-D, the Oticon Adapto D, the Oticon Delta 8000, the Phonak Supero 412, the Phonak Una M, the Sonic Innovations Balance, the Starkey Axent II, the Starkey S-Series 9, the Unitron Conversa, and the Widex Senso Diva.

24. On information and belief, Siemens Audiologische Technik GmbH has offered to sell or sold in, or imported into, the United States the Motion 500M hearing aid for use, offer for sale, and sale by Siemens Hearing Instruments, Inc.

25. On information and belief, GN ReSound A/S has offered to sell or sold in, or imported into, the United States the Canta 780-D hearing aid for use, offer for sale, and sale by GN Hearing Care Corporation.

26. On information and belief, Oticon A/S has offered to sell or sold in, or imported into, the United States the Adapto D and Delta 8000 hearing aids for use, offer for sale, and sale by Oticon, Inc.

27. On information and belief, Phonak AG has offered to sell or sold in, or imported into, the United States the Supero 412 and Una M hearing aids for use, offer for sale, and sale by Phonak, LLC.

28. On information and belief, Unitron Hearing Ltd. has offered to sell or sold in, or imported into, the United States the Conversa hearing aid for use, offer for sale, and sale by Unitron Hearing, Inc.

29. On information and belief, Widex A/S has offered to sell or sold in, or imported into, the United States the Senso Diva hearing aid for use, offer for sale, and sale by Widex Hearing Aid Co. Inc.

30. On information and belief, hearing aids offered for sale or sold in, or imported into, the United States by Defendants utilize complex signal processing algorithms that have been implemented in software that is stored in microprocessors in the hearing aids.

31. On information and belief, none of the Defendants has published information disclosing in any detail the signal processing algorithms embodied in their hearing aids, but rather treat such information as highly confidential and proprietary.

32. On information and belief, each of the Defendants attempts to restrict distribution of its hearing aids, together with the equipment and software necessary to program such hearing aids, to audiologists who fit and sell the hearing aids to end users through face-to-face, in-person consultations. Therefore, the Defendants' hearing aids and the means to program them for evaluation are not readily available to Northrop.

33. On information and belief, there further is no practical or economically viable analytical technique available to definitively establish from the hearing aids themselves, in a reliable and effective manner, whether they use the invention as claimed in the '560 patent. Nor is it possible to make such a determination based upon publicly available information.

34. Northrop was able to obtain access to certain hearing aids of Defendants, including those identified above in paragraph 23, for evaluation for possible infringement of the '560 patent. As a result of such evaluation, Northrop determined that the operation and performance of these hearing aids is consistent with use of the invention claimed in the '560 patent.

35. In the absence of further information from Defendants to establish whether hearing aids offered for sale or sold in, or imported into, the United States by Defendants are or are not within the lawful scope of one or more claims of the '560 patent, Northrop resorts to the judicial process and the aid of discovery to obtain under appropriate judicial safeguards such information to confirm its belief, and to present to the Court evidence, that each of the Defendants has infringed one or more claims of the '560 patent.

36. Northrop has not authorized any of the Defendants to import into the United States, or to make, use, offer for sale or sell in the United States, any hearing aid that comes within the scope of any of the claims of the '560 patent.

37. Based upon the foregoing averments, Northrop believes that the Defendants have engaged in infringing conduct by directly infringing one or more claims of the '560 patent, and that the Defendants have caused and will continue to cause Northrop irreparable injury and financial damage in an amount to be shown by proof at trial. Each of the Defendants is liable to Northrop in an amount that adequately compensates Northrop for any respective acts of infringement, which by law cannot be less than a reasonable royalty.

38. Based upon the foregoing averments, Northrop believes that the Defendants have deprived Northrop of its exclusive rights under the '560 patent, and each of the Defendants will continue to do so unless enjoined by this Court.

PRAYER FOR RELIEF

WHEREFORE, Northrop prays for relief against each of the Defendants as follows:

a. For a judgment that each of the Defendants has infringed and is infringing the '560 patent;

b. That each of the Defendants and its officers, agents, servants, employees, and attorneys, and others who are in active concert or participation with any of the foregoing, be preliminarily and thereafter permanently enjoined and restrained from further infringement of the '560 patent;

c. That Northrop be awarded damages adequate to compensate for the Defendants' wrongful acts in infringing the '560 patent, in an amount to be determined at trial;

d. That Northrop be granted pre-judgment and post-judgment interest on the damages caused as a result of the Defendants' infringement of the '560 patent;

e. That the Court declare this to be an exceptional case under 35 U.S.C. § 285;

f. That Northrop be awarded its reasonable attorneys' fees and expenses in this action;

g. That costs be awarded to Northrop; and

h. That Northrop be granted such other and further relief as this Court deems just and proper under the circumstances.

Dated: April 26, 2010

SHEPPARD MULLIN RICHTER & HAMPTON LLP

By _____
GARY A. CLARK
Attorneys for Plaintiff
NORTHROP GRUMMAN
SYSTEMS CORPORATION

DEMAND FOR JURY TRIAL

Northrop hereby demands a jury trial on all issues triable of right by a jury.

Dated: April 26, 2010

SHEPPARD MULLIN RICHTER & HAMPTON LLP

By _____
GARY A. CLARK
Attorneys for Plaintiff
NORTHROP GRUMMAN
SYSTEMS CORPORATION

US005396560A

United States Patent [19]

Arcos et al.

[11] Patent Number: 5,396,560

[45] Date of Patent: Mar. 7, 1995

[54] **HEARING AID INCORPORATING A NOVELTY FILTER**

[75] Inventors: **John T. Arcos**, Long Beach; **Mark T. Core**, Placentia; **James G. Harrison**, Cypress, all of Calif.

[73] Assignee: **TRW Inc.**, Redondo Beach, Calif.

[21] Appl. No.: **40,709**

[22] Filed: **Mar. 31, 1993**

[51] **Int. Cl.**[6] **H04R 25/00**

[52] **U.S. Cl.** **381/68**; 381/68.4; 381/94

[58] **Field of Search** 381/107, 108, 82, 83, 381/74, 92, 94, 68.2, 68.4, 68, 57

[56] **References Cited**

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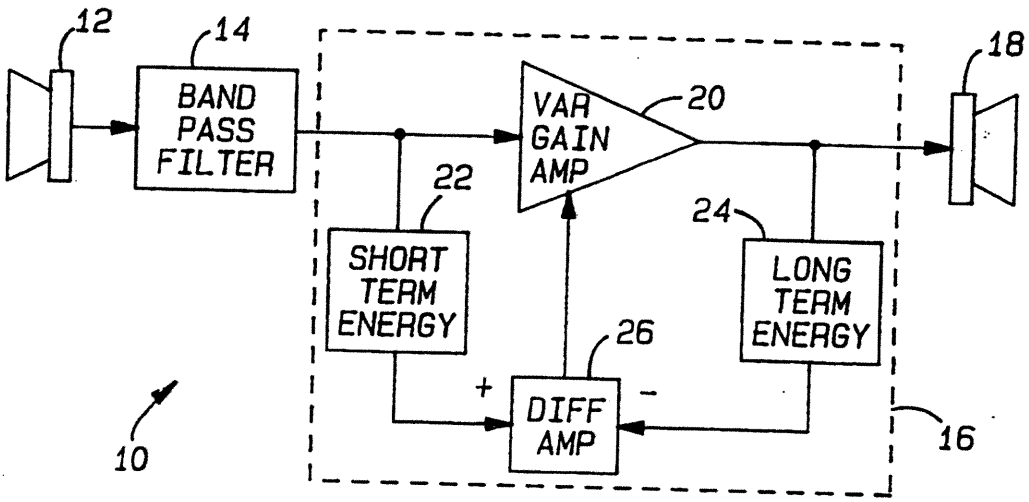
FET principles, experiments, and projects, by Eward M. Noll, first printing 1975, 2nd edition pp. 221, 222.

Primary Examiner—Curtis Kuntz
Assistant Examiner—Huyen D. Le

[57] **ABSTRACT**

This invention discloses a hearing aid including one or more amplification channels in which each amplification channel includes a bandpass filter establishing the frequency range of that particular channel. Each amplification channel further includes a variable gain amplifier, a short-term energy averaging circuit, a long-term energy averaging circuit and a difference amplifier. An acoustical signal sensed by a microphone associated with the hearing aid is applied to the bandpass filter which then applies a signal within the particular frequency range of that filter to the variable gain amplifier and the short-term energy averaging circuit. An output from the variable gain amplifier is applied to the long-term energy averaging circuit and an earphone for enabling a hearing aid user to perceive the sounds sensed by the microphone. Steady state signals perceived by the microphone are integrated by the long-term energy averaging circuit which causes the difference amplifier to reduce the gain of the variable gain amplifier, thus decreasing the steady state sound. A novel sound sensed by the microphone is integrated by the short-term energy averaging circuit which causes the difference amplifier to increase the gain of the variable gain amplifier. In this manner, the gain of the amplifier is increased for desirable sounds and decreased for background noise.

19 Claims, 2 Drawing Sheets



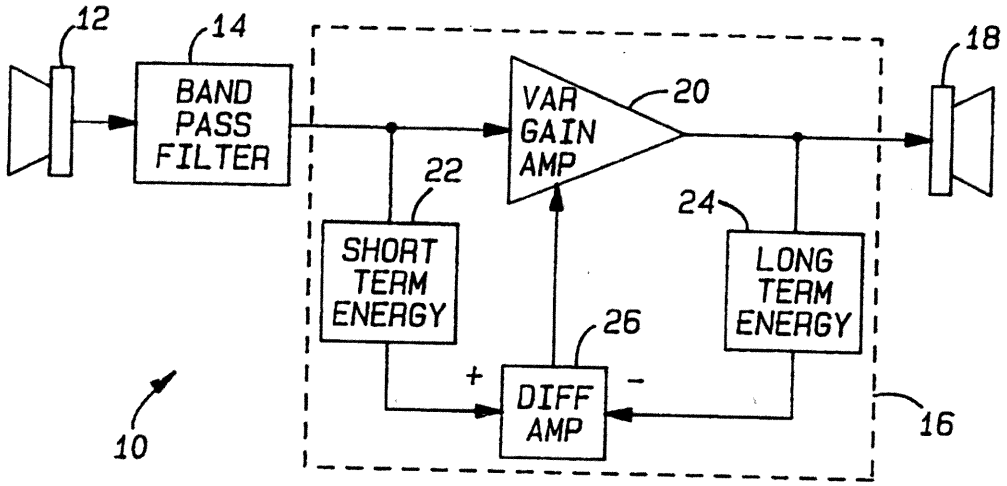
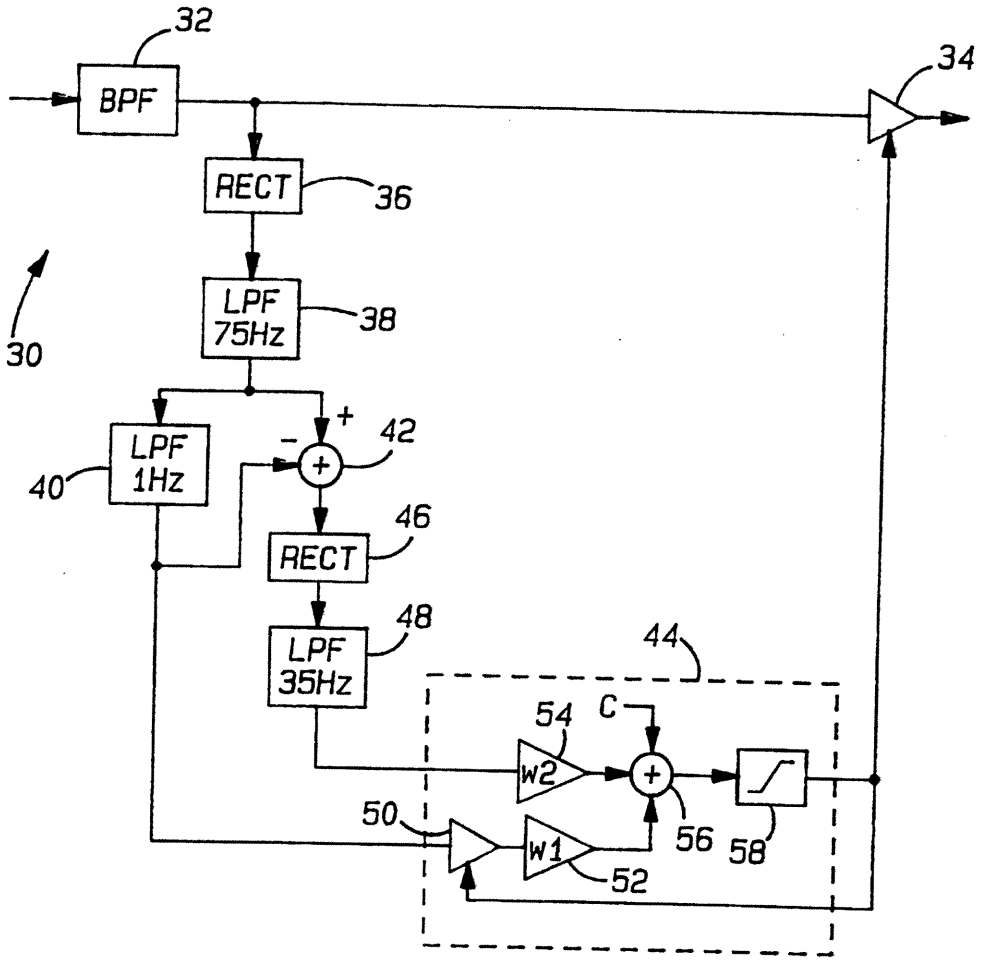

12
14
BAND PASS FILTER
VAR GAIN AMP
20
18
22
SHORT TERM ENERGY
24
LONG TERM ENERGY
26
+
-
DIFF AMP
16
10

Fig-1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BPF
34
RECT
36
LPF 75Hz
38
30
LPF 1Hz
40
+
-
42
RECT
46
LPF 35Hz
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54
C
W2
56
58
50
W1
52

Fig-2

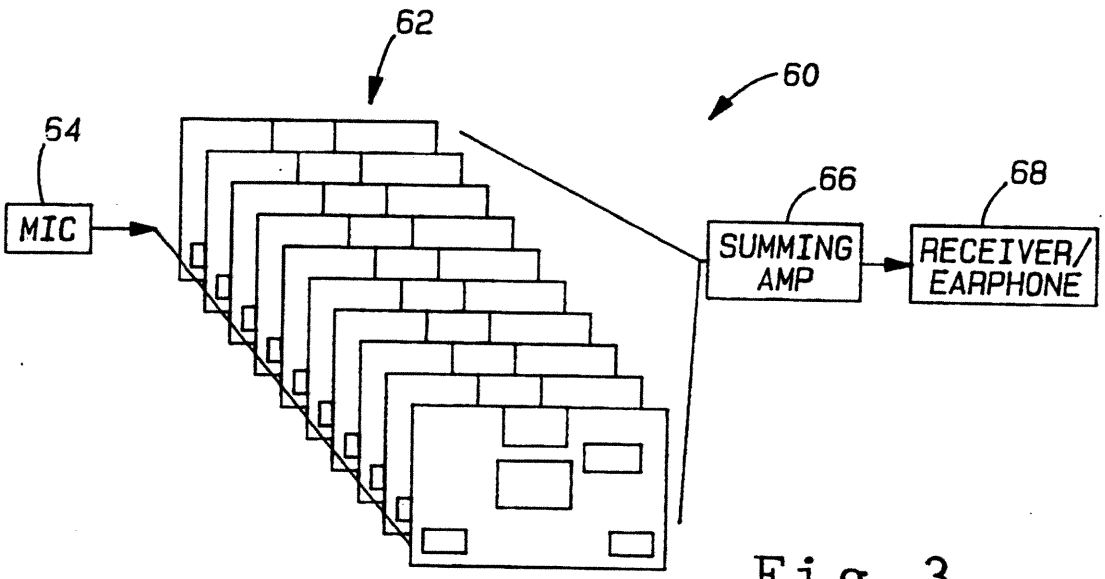

Fig-3

HEARING AID INCORPORATING A NOVELTY FILTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a hearing aid and, more particularly, to a hearing aid incorporating a novelty filter providing adaptable gain in a plurality of channels.

2. Discussion of the Related Art

Conventional hearing aids come in a variety of shapes and styles. Typically, however, every hearing aid will consist of a microphone, an amplifier, and an ear phone, sometimes known as a driver. The microphone will be directed towards the environment and the ear phone will be directed towards a user's ear drum such that environmental sounds sensed by the microphone will be amplified by the amplifier and delivered to the ear phone to enable the user to perceive these sounds. More sophisticated hearing aid models may incorporate several channels of amplification, each channel being assigned a particular frequency band by a bandpass filter within the normal hearing range. Whatever designs and features a hearing aid incorporates, a number of problems must be addressed in design. Typical problems encountered by a hearing aid user include feedback between the microphone and the ear phone, inappropriate gain settings of the amplifier in one or more of the channels, and poor battery life.

Feedback occurs due to the fact that the hearing aid is a high gain (30 dB or more) device in which the microphone and the ear phone are generally spaced less than one inch apart from each other within a common housing. When a hearing aid is fitted to a particular user, usually the seal between the hearing aid housing and the user's ear canal ensures acoustic isolation between the microphone and the earphone, thus substantially eliminating feedback. However, through normal use of the aid and age of the user, certain factors, such as the shape of the ear canal, cause loss of isolation between the microphone and the earphone, thus producing feedback. Consequently, the hearing aid may have to be replaced or readjusted.

Many conventional hearing aids use a number of channels of amplification having a fixed gain setting for each channel. Typically, the gain is preset by the hearing aid dealer or audiologist. Environmental acoustics or high levels of noise may all conspire to make gain settings which are ideal at the hearing aid dealer's office inappropriate for the particular idiosyncracies of the user's environment. Consequently, since the gain is preset, a hearing aid user will not realize the most desirable gain for each channel of the hearing aid in the environments the user may encounter. Additionally, each amplification channel amplifies not only the desirable sounds, but those of unwanted background noise as well. Certain hearing aids may, however, incorporate automatic gain control (AGC) or output limiting in which the hearing aid automatically limits the intensity of the amplification of a sound.

What is needed then is a hearing aid which compensates for feedback, and which provides an adaptively adjustable gain in each channel in order to selectively amplify desirable sounds. It is therefore an object of the present invention to provide such a hearing aid.

SUMMARY OF THE INVENTION

This invention discloses a hearing aid incorporating one or more channels of amplification in which each channel includes a novelty filter. An acoustic input is converted by a microphone associated with the hearing aid to a proportionate electrical signal which is applied to a bandpass filter associated with each channel which establishes the frequency range for that particular channel. In each channel of amplification, an output from the bandpass filter associated with that channel is applied to a variable gain amplifier, a short-term energy averaging circuit and a long-term energy averaging circuit. An output of the variable gain amplifier is applied to a summing amplifier for summing together the different channels which in turn has an output applied to an earphone. An output of both the short-term energy averaging circuit and the long-term energy averaging circuit is applied to a difference amplifier which has an output as an adjustment to the gain of the variable gain amplifier.

The long-term energy averaging circuit is an integrator which integrates the level of steady state sounds, representing background noise that does not change significantly over time, having a power spectrum with energy within the particular frequency range. An output of the long-term energy averaging circuit is applied to the variable gain amplifier such that a high long-term energy average tends to force the difference amplifier output negative, thus reducing the gain of the variable gain amplifier and reducing the level of background noise. When a novel acoustical event occurs having a varying power spectrum, such as a person speaking in the din of background noise and having energy within the frequency range, the short-term energy averaging circuit will drive the difference amplifier output more positive, thus increasing the gain of the variable gain amplifier. Consequently, novel or desirable sounds experience high gain, while steady state sounds experience low gain. In a similar fashion, feedback is sensed by each amplifier channel as a steady state sound typically within a particular amplification channel within the system. Because it is a steady state sound, the long-term energy average is increased, which reduces the gain in that particular band, thus reducing feedback.

Additional objects, advantages, and features of the present invention will become apparent from the following description and appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram of a hearing aid according to a preferred embodiment of the present invention;

FIG. 2 is a more detailed schematic block diagram of a particular hearing aid amplification channel according to a preferred embodiment of the present invention; and

FIG. 3 is a schematic block diagram of a hearing aid incorporating a plurality of different amplification channels according to a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following discussion of the preferred embodiments concerning a hearing aid incorporating a novelty filter is merely exemplary in nature and is in no way

intended to limit the invention or its applications or uses.

First turning to FIG. 1, a schematic block diagram of a hearing aid circuit 10 according to one preferred embodiment of the present invention is shown. The hearing aid circuit 10 includes a microphone 12 for sensing acoustical events and generating an electrical signal indicative of these events. The electrical signals from the microphone 12 are applied to a bandpass filter 14. The bandpass filter 14 filters the electrical signals and provides signals representative of a predetermined audible frequency range to an amplifier circuit 16. The amplifier circuit 16 amplifies the signals and applies them to an earphone 18, thus enabling a hearing aid user to perceive the sounds as sensed by the microphone 12. This system will be configured within a housing (not shown) adaptable to fit within an ear canal of a user. The amplification circuit 16 represents one channel of amplification, but it will be understood that typically hearing aids will include a plurality of these amplification channels, each including a separate frequency range as set by a particular bandpass filter.

The amplification circuit 16 includes a variable gain amplifier 20 and a short-term energy averaging circuit 22, both of which receive the electrical signal from the bandpass filter 14. An output of the variable gain amplifier 20 is applied to the earphone 18 and a long-term energy averaging circuit 24. Outputs from both the short-term energy averaging circuit 22 and the long-term energy averaging circuit 24 are applied to a positive and a negative input of a difference amplifier 26, respectively. The difference amplifier 26 has an output which provides control of the gain of the variable gain amplifier 20. The variable gain amplifier 20 and the difference amplifier 26 are conventional amplifiers in the art and thus, their specifics need not be discussed here. Both the short-term energy averaging circuit 22 and the long-term energy averaging circuit 24 are conventional integrators, well known to those skilled in the art, having the appropriate time constants which will integrate signals over a certain period of time. In other words, an acoustical event which has a power spectrum which does not change significantly over time, say for more than ten seconds, will be integrated by the long-term energy averaging circuit 24 in order to provide an output at the negative input of the difference amplifier 26. Likewise, the short-term energy averaging circuit 22 will have a much smaller time constant such that novel acoustical events which have power spectrums substantially continuously changing over time will be integrated and thus, the short-term energy averaging circuit 22 will provide an output at the positive input of the differential amplifier 26.

It is noted that the electrical configuration of the short-term energy averaging circuit 22 and the long-term energy averaging circuit 24 with respect to receiving the filtered signal from the bandpass filter 14 is not critical in that both of the short-term energy averaging circuit 22 and the long-term energy averaging circuit 24 can receive the electrical signal prior to being amplified by the variable gain amplifier 26. The short-term energy averaging circuit 22 should receive its input signal before the variable gain amplifier 20 to avoid an unstable positive feedback situation. Because long term energy decreases the gain of the amplifier 20, its input signal can come after the variable gain amplification by the amplifier 20 so that a stable negative feedback condition results.

In operation, the microphone 12 will sense acoustical events from the environment. The bandpass filter 14 will limit the signals to a particular range. The long-term energy averaging circuit 24 integrates acoustical events having a substantially continuous power spectrum and produces an output which tends to force the output of the difference amplifier 26 negative, thus reducing the gain of the variable gain amplifier 20. When a novel acoustic event occurs of a changing power spectrum, having energy within the range of the bandpass filter 14, the short-term energy averaging circuit 22 will provide an output signal to the difference amplifier 26 which causes the difference amplifier 26 to increase the gain of the variable gain amplifier 20. Consequently, the amplifier circuit 16 operates as a novelty filter. In this manner, novel, and generally desirable, sounds experience high gain, while steady state, generally undesirable background noise and sounds experience low gain. Therefore, a user will affectively perceive only those sounds which are desirable.

In practice, a hearing aid user in a room filled with continuous noise would experience a gradual decrease in the perceived sound as the hearing aid computed the long-term average of the noise and reduced the gain of the hearing aid accordingly. As a novel event occurred, such as a person speaking, the hearing aid would increase the gain within those channels corresponding to the frequency band of the speech, thus enabling the user to perceive the sound.

In the same manner, the amplifier circuit 16 provides automatic feedback cancellation. If feedback occurs, the feedback signal will be sensed by the amplifier circuit 16 as a steady state sound typically within a single channel of the circuit 10. Because it is a steady state sound, the feedback increases the long-term average, thus reducing the gain within that band. Reduced gain in a particular band eliminates the feedback without affecting the signals within other bands.

Turning to FIG. 2, a more detailed illustration to that of the hearing aid circuit 10 is shown. Specifically, a hearing aid circuit 30 is shown, according to one preferred embodiment, in a schematic block diagram form in which a more detailed illustration of the amplifier circuit 16 is given. As with the hearing aid circuit 10 above, the hearing aid circuit 30 includes a bandpass filter 32 operating in the same fashion as the bandpass filter 14, and a variable gain amplifier 34 operating in the same manner as the variable gain amplifier 20, above. The microphone 12 and the speaker 18 are not shown in FIG. 2, but it will be understood that they will be included in the same manner as to that of the hearing aid circuit 10.

As above, a filtered electrical signal of an acoustical event is output from the bandpass filter 32 and applied to the variable gain amplifier 34. Additionally, this signal is also applied to a rectifier 36 and a first low pass filter 38. The rectifier 36 is provided to allow electrical current to travel in one direction, and the low pass filter 38 is provided to prevent high frequency signals from traveling to the subsequent electrical components, here signals above 75 Hz. Consequently, the combination of the rectifier 36 and the low pass filter 38 only allows signals to pass below a certain frequency. The operation and electrical configuration of rectifiers and low pass filters are well known to those skilled in the art, and therefore these devices need not be discussed in any subsequent detail.

An output signal from the low pass filter **38** is split and applied to a second low pass filter **40** and a summation junction **42**. The signal output from the low pass filter **40** represents a long-term energy averaging signal and the signal output from the low-pass filter **48** represents a short-term energy averaging signal.

Once the signal from the low pass filter **38** is filtered by the low pass filter **40**, here to a level below 1 Hz, it is applied to a difference amplifier circuit **44** and the summation junction **42** as a negative input. The filtered signal from the low pass filter **38** is applied to the summation junction **42** as a positive input such that the output of the summation junction **42** is a summation of the signal from the low pass filter **40** and the signal from the low pass filter **38**. The output signal from the summation junction **42** is applied to a rectifier **46** and then to a third low pass filter **48** which again filters out signals above a predetermined value, here signals above 35 Hz. The output of the low pass filter **48** is applied to the difference amplifier circuit **44** as a short-term average energy input. The frequencies of the low pass filters **38**, **40** and **48** are merely illustrations, and thus could be different for different applications.

Within the difference amplifier **44**, the long-term average energy input from the low pass filter **40** is applied to a first operational amplifier **50** and a second operational amplifier **52**. The amplifier **52** has an inverted weighting function which multiplies the signal from the amplifier **50** by a particular predetermined constant and inverts it in order to decrease the output of the difference amplifier **44**. Likewise, the filtered output from the low pass filter **48** is applied to a third amplifier **54** which multiplies this signal by a predetermined weighting function in order to increase the output of the difference amplifier **44**. The outputs of the amplifier **52** and the amplifier **54** are applied to a summation junction **56** for increasing and decreasing the output of the difference amplifier **44** as just described. Also applied to the summation junction **56** is an offset signal, here represented by input C. The offset signal sets a predetermined output of the difference amplifier **44** as a nominal gain.

The output of the summation circuit **56** is applied to a sigmoidal transfer function circuit **58**. The transfer function circuit **58** is a saturated gain circuit which clips the output of the difference amplifier **44** to a level below a predetermined value. Transfer function circuits of this type are well known in the art, and thus do not need to be described in any detail here. The output of the difference amplifier **44** is applied to the variable gain amplifier **34** in order to adjust the output of the circuit **30** in the same manner as that discussed above for variable amplifier **20**. Additionally, the output of the difference amplifier **44** is applied to the gain control of the amplifier **50** in order to adjust the long-term signal being applied to the difference amplifier **44**. Also, the input to the amplifier **52** from the circuit **58** effectively provides a long term energy averaging signal from the output side of the variable gain amplifier **34**.

FIG. **3** shows a hearing aid circuit **60** incorporating a plurality of amplification channels **62**, here eleven. A microphone **64** provides an electrical signal to each of the amplification channels indicative of the acoustical event it senses. A bandpass filter (not shown) in each of the amplification channels **62** eliminates all frequencies except those desired for that channel. An output of each of the amplification channels **62** is applied to a summing amplifier **66** which adds all of the particular frequencies together. An output of the summing amplifier **66** is applied to an earphone **68**, thus enabling the hearing aid user to perceive the sounds picked up by the microphone **64**. Additionally, output limiting circuitry or automatic gain control can be incorporated within the summing amplifier **66** in order to provide a volume control feature.

It is generally desirable in this type of system to incorporate several amplification channels in order to provide a wider degree of resolution. Because a novel acoustical event in each channel will cause the gain of the entire channel to increase, it is desirable to provide a number of channels because background noise in other channels will not be increased as the background noise is increased in a specific channel having the range of the novel acoustical event. It is noted that the specific frequency range of each channel can be tailored to specific applications in that each different amplification channel does not have to cover a band of frequencies of the same magnitude as other channels. Consequently, a versatile hearing aid can be realized.

The foregoing discussion discloses and describes merely exemplary embodiments of the present invention. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations can be made therein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A hearing aid comprising:

a microphone operable to sense acoustical events and convert them to proportionate electrical signals;

a variable gain amplifier operable to amplify the electrical signals from the microphone and provide an amplified output of that signal depending on the gain of the amplifier;

a difference amplifier operable to adjust the gain of the variable gain amplifier;

a long-term energy averaging circuit operable to sense substantially steady state acoustical events received by the microphone and force the difference amplifier to reduce the gain of the variable gain amplifier in view of the steady state signals;

a short-term energy averaging circuit operable to sense novel acoustical signals received by the microphone and force the difference amplifier to increase the gain of the variable gain amplifier in view of the novel signals; and

an earphone operable to receive an output signal from the variable gain amplifier and convert it to an audible sound.

2. The hearing aid according to claim **1** further comprising a plurality of amplification channels in which each amplification channel includes a bandpass filter operable to set a frequency band range of the particular amplification channel, wherein each amplification channel further includes a separate variable gain amplifier, short-term energy averaging circuit, long-term energy averaging circuit and difference amplifier.

3. The hearing aid according to claim **2** in which an output from each of the plurality of amplification channels is applied to a summing amplifier, said summing amplifier being operable to apply a summed signal to the earphone.

4. The hearing aid according to claim **1** wherein each of the long-term energy averaging circuit and the short-term energy averaging circuit are integrating circuits,

wherein the long-term energy averaging circuit integrates electrical signals having a power spectrum which does not change significantly over time and the short-term energy averaging circuit integrates signals having a power spectrum that does significantly changes over time.

5. The hearing aid according to claim 1 further comprising an automatic gain control circuit operable to limit the output of the hearing aid below a predetermined intensity.

6. The hearing aid according to claim 1 wherein the difference amplifier includes a first weighting amplifier and a second weighting amplifier, said first weighting amplifier being a positively weighted amplifier for applying a positively weighted signal from the short-term energy averaging circuit to a summation junction and said second weighting amplifier being a negative weighting amplifier for providing an inverse signal from the long-term energy averaging circuit to the summation junction.

7. The hearing aid according to claim 6 wherein the difference amplifier further includes a sigmoidal transfer function circuit for providing a saturable gain limitation to the output of the difference amplifier.

8. An amplifying circuit comprising:

a variable gain amplifier receiving an input signal and providing an amplified output of the input signal depending on the gain of the amplifier;

a difference amplifier having an output which adjusts the gain of the variable gain amplifier;

a long-term energy averaging circuit applying an input signal to a negative input of the difference amplifier for decreasing the gain of the variable gain amplifier, said long-term energy averaging circuit integrating substantially steady state signals of the input signal; and

a short-term energy averaging circuit applying an input signal to a positive input of the difference amplifier for increasing the gain of the variable gain amplifier, said short-term energy averaging circuit integrating novel signals of the input signal.

9. The amplifying circuit according to claim 8 wherein the amplification circuit is associated with a hearing aid device, wherein the hearing aid device includes a microphone which senses acoustical events from the environment and converts them to electrical signals and applies the electrical signals as the input signal to the variable gain amplifier, said hearing aid further including an earphone which receives an output from the variable gain amplifier and converts it to an audible sound to be perceived by a hearing aid user.

10. The amplifying circuit according to claim 8 further comprising a bandpass filter, said band pass filter limiting the input to the variable gain amplifier to a predetermined frequency range.

11. The amplifying circuit according to claim 8 wherein each of the long-term energy averaging circuit and the short-term energy averaging circuit are integrating circuits, wherein the long-term energy averaging circuit integrates electrical signals having a power spectrum which does not change significantly over time and the short-term energy averaging circuit integrates signals having a power spectrum that does significantly changes over time.

12. The amplifying circuit according to claim 8 wherein the difference amplifier includes a first weighting amplifier and a second weighting amplifier, said first weighting amplifier being a positively weighted amplifier for applying a positively weighted signal from the short-term energy averaging circuit to a summation junction and said second weighting amplifier being a negative weighting amplifier for providing an inverse signal from the long-term energy averaging circuit to the summation junction.

13. A method of amplifying an acoustical event, said method comprising the steps of:

converting the acoustical event to a proportionate electrical signal:

applying the electrical signal as an input to a variable gain amplifier in order to amplify the signal depending on the gain of the amplifier;

applying an output from a difference amplifier to the variable gain amplifier in order to adjust the gain of the variable gain amplifier;

applying an output from a long-term energy averaging circuit to a negative input of the difference amplifier, wherein the long-term energy averaging circuit senses steady state portions of the signal in order to force the difference amplifier to reduce the gain of the variable gain amplifier;

applying an output from a short-term energy averaging circuit to a positive input of the difference amplifier, wherein the short-term energy averaging circuit integrates novel portions of the signal in order to force the difference amplifier to increase the gain of the variable gain amplifier; and

converting an output of the variable gain amplifier to a proportionate acoustical signal.

14. The method according to claim 13 wherein the step of converting the acoustical event to an electrical signal includes using a microphone to sense the acoustical events and convert them to the electrical signals.

15. The method according to claim 13 wherein the step of converting the output of the variable gain amplifier includes using an earphone to convert the output from the variable gain amplifier to an audible sound.

16. The method according to claim 13 further comprising the step of applying the converted electrical signal to a plurality of channels, each of the channels including a band pass filter for limiting the frequencies of each channel to a particular frequency range, each channel further including a variable gain amplifier, a difference amplifier, a short-term energy averaging circuit, and a long-term energy averaging circuit.

17. The method according to claim 16 further comprising the step of applying an output from each of the channels to a summing junction prior to the electrical signals being converted to the acoustical signal.

18. The method according to claim 13 further comprising the step of applying the electrical signal to an automatic gain control circuit for limiting the output intensity of the signal.

19. The method according to claim 13 wherein the long-term energy averaging circuit integrates electrical signals having a power spectrum which does not significantly change over time and the short-term energy averaging circuit integrates signals having a power spectrum that does change over time.

* * * * *

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UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

NORTHROP GRUMMAN SYSTEMS CORPORATION, a corporation, PLAINTIFF(S). V. SIEMENS AUDIOLOGISCHE TECHNIK GMBH, a corporation; SIEMENS HEARING INSTRUMENTS, INC., a corporation; GN RESOUND A/S, a corporation; GN HEARING CARE CORPORATION, a corporation; OTICON A/S, a corporation; OTICON, INC., a corporation; PHONAK AG, a corporation; PHONAK, LLC, a limited liability company; SONIC INNOVATIONS, INC., a corporation; STARKEY LABORATORIES, INC., a corporation; UNITRON HEARING LTD., a corporation; UNITRON HEARING, INC., a corporation; WIDEX A/S, a corporation; WIDEX HEARING AID CO. INC., a corporation; and DOES 1 through 10, inclusive, DEFENDANT(S).	CASE NUMBER CV10-03120 GAF (FFMx) **SUMMONS**

TO: DEFENDANT(S) NAMED ABOVE

A lawsuit has been filed against you.

Within 21 days after service of this summons on you (not counting the day you received it), you must serve on the plaintiff an answer to the attached ☒ complaint ☐ _____ amended complaint ☐ counterclaim ☐ cross-claim or a motion under Rule 12 of the Federal Rules of Civil Procedure. The answer or motion must be served on the plaintiff's attorney, Gary A. Clark, whose address is 333 South Hope Street, 43rd Floor, Los Angeles, California 90071-1422. If you fail to do so, judgment by default will be entered against you for the relief demanded in the complaint. You also must file your answer or motion with the court.

Clerk, U.S. District Court

Dated: 26 APR 2010

By: _____
Deputy Clerk

(Seal of the Court)

[Use 60 days if the defendant is the United States or a United States agency, or is an officer or employee of the United States. Allowed 60 days by Rule 12(a)(3)].

UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA
CIVIL COVER SHEET

I (a) PLAINTIFFS (Check box if you are representing yourself ☐)
NORTHROP GRUMMAN SYSTEMS CORPORATION, a corporation

DEFENDANTS
SIEMENS AUDIOLOGISCHE TECHNIK GMBH, a corporation; SIEMENS HEARING INSTRUMENTS, INC., a corporation; GN RESOUND A/S, a corporation; GN HEARING CARE CORPORATION, a corporation; OTICON A/S, a corporation; OTICON, INC., a corporation; PHONAK AG, a corporation; PHONAK, LLC, a limited liability company; SONIC INNOVATIONS, INC., a corporation; STARKEY LABORATORIES, INC., a corporation; UNITRON HEARING LTD., a corporation; UNITRON HEARING, INC., a corporation; WIDEX A/S, a corporation; WIDEX HEARING AID CO. INC., a corporation; and DOES 1 through 10, inclusive

(b) Attorneys (Firm Name, Address and Telephone Number. If you are representing yourself, provide same.)
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Telephone: 213-620-1780

Attorneys (If Known)

II. BASIS OF JURISDICTION (Place an X in one box only.)
☐ 1 U.S. Government Plaintiff ☒ 3 Federal Question (U.S. Government Not a Party)
☐ 2 U.S. Government Defendant ☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES - For Diversity Cases Only (Place an X in one box for plaintiff and one for defendant.)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated or Principal Place of Business in this State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated and Principal Place of Business in Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. ORIGIN (Place an X in one box only.)
☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify): ☐ 6 Multi-District Litigation ☐ 7 Appeal to District Judge from Magistrate Judge

V. REQUESTED IN COMPLAINT: JURY DEMAND: ☒ Yes ☐ No (Check 'Yes' only if demanded in complaint.)
CLASS ACTION under F.R.C.P. 23: ☐ Yes ☒ No ☒ **MONEY DEMANDED IN COMPLAINT: $** according to proof

VI. CAUSE OF ACTION (Cite the U. S. Civil Statute under which you are filing and write a brief statement of cause. Do not cite jurisdictional statutes unless diversity.)
35 U.S.C. § 271 (patent infringement)

VII. NATURE OF SUIT (Place an X in one box only.)

OTHER STATUTES
☐ 400 State Reapportionment
☐ 410 Antitrust
☐ 430 Banks and Banking
☐ 450 Commerce/ICC Rates/etc.
☐ 460 Deportation
☐ 470 Racketeer Influenced and Corrupt Organizations
☐ 480 Consumer Credit
☐ 490 Cable/Sat TV
☐ 810 Selective Service
☐ 850 Securities/Commodities/ Exchange
☐ 875 Customer Challenge 12 USC 3410
☐ 890 Other Statutory Actions
☐ 891 Agricultural Act
☐ 892 Economic Stabilization Act
☐ 893 Environmental Matters
☐ 894 Energy Allocation Act
☐ 895 Freedom of Info. Act
☐ 900 Appeal of Fee Determination Under Equal Access to Justice
☐ 950 Constitutionality of State Statutes

CONTRACT
☐ 110 Insurance
☐ 120 Marine
☐ 130 Miller Act
☐ 140 Negotiable Instrument
☐ 150 Recovery of Overpayment & Enforcement of Judgment
☐ 151 Medicare Act
☐ 152 Recovery of Defaulted Student Loan (Excl. Veterans)
☐ 153 Recovery of Overpayment of Veteran's Benefits
☐ 160 Stockholders' Suits
☐ 190 Other Contract
☐ 195 Contract Product Liability
☐ 196 Franchise

REAL PROPERTY
☐ 210 Land Condemnation
☐ 220 Foreclosure
☐ 230 Rent Lease & Ejectment
☐ 240 Torts to Land
☐ 245 Tort Product Liability
☐ 290 All Other Real Property

TORTS PERSONAL INJURY
☐ 310 Airplane
☐ 315 Airplane Product Liability
☐ 320 Assault, Libel & Slander
☐ 330 Fed. Employers' Liability
☐ 340 Marine
☐ 345 Marine Product Liability
☐ 350 Motor Vehicle
☐ 355 Motor Vehicle Product Liability
☐ 360 Other Personal Injury
☐ 362 Personal Injury-Med Malpractice
☐ 365 Personal Injury-Product Liability
☐ 368 Asbestos Personal Injury Product Liability

IMMIGRATION
☐ 462 Naturalization Application
☐ 463 Habeas Corpus-Alien Detainee
☐ 465 Other Immigration Actions

TORTS PERSONAL PROPERTY
☐ 370 Other Fraud
☐ 371 Truth in Lending
☐ 380 Other Personal Property Damage
☐ 385 Property Damage Product Liability

BANKRUPTCY
☐ 22 Appeal 28 USC 158
☐ 423 Withdrawal 28 USC 157

CIVIL RIGHTS
☐ 441 Voting
☐ 442 Employment
☐ 443 Housing/Accommodations
☐ 444 Welfare
☐ 445 American with Disabilities – Employment
☐ 446 American with Disabilities – Other
☐ 440 Other Civil Rights

PRISONER PETITIONS
☐ 510 Motions to Vacate Sentence Habeas Corpus
☐ 530 General
☐ 535 Death Penalty
☐ 540 Mandamus/ Other
☐ 550 Civil Rights
☐ 555 Prison Condition

FORFEITURE / PENALTY
☐ 610 Agriculture
☐ 620 Other Food & Drug
☐ 625 Drug Related Seizure of Property 21 USC 881
☐ 630 Liquor Laws
☐ 640 R.R.& Truck
☐ 650 Airline Regs
☐ 660 Occupational Safety /Health
☐ 690 Other

LABOR
☐ 710 Fair Labor Standards Act
☐ 720 Labor/Mgmt. Relations
☐ 730 Labor/Mgmt. Reporting & Disclosure Act
☐ 740 Railway Labor Act
☐ 790 Other Labor Litigation
☐ 791 Empl. Ret. Inc. Security Act

PROPERTY RIGHTS
☐ 820 Copyrights
☒ 830 Patent
☐ 840 Trademark

SOCIAL SECURITY
☐ 61 HIA(1395ff)
☐ 862 Black Lung (923)
☐ 863 DIWC/DIWW 405(g))
☐ 864 SSID Title XVI
☐ 865 RSI (405(g))

FEDERAL TAX SUITS
☐ 870 Taxes (U.S. Plaintiff or Defendant)
☐ 871 IRS-Third Party 26 USC 7609

CV 10-03120

FOR OFFICE USE ONLY: Case Number: -
AFTER COMPLETING THE FRONT SIDE OF FORM CV-71, COMPLETE THE INFORMATION REQUESTED BELOW.